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EFFECTS OF ANTI-SEIZING

COMPOUNDS AND LUBRICANTS

ON HIGH TEMPERATURE

ALLOYS AT ELEVATED TEMPERATURES

REPORT A078 SERIAL NO. 5

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EFFECTS OF ANTI-SEIZING

COMPOUNDS AND LUBRICANTS

ON HIGH TEMPERATURE

ALLOYS AT ELEVATED TEMPERATURES

REPORT	A078	SERIAL NO.	5

# **MCDONNELL**

This report was prepared under Contract Number AF33(657)-11215 and BPSN: 63-6899-7381-738103. Additional information pertaining to any data contained herein may be obtained from the Directorate of Materials and Processes (ASRCEM-1), Acconautical Systems Division, Air Force Systems Command, United States Air Force, Wright-Patterson Air Force Base, Ohio, or McDonnell Aircraft Corporation, St. Louis, Missouri

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# EFFECTS OF ANTISEIZIEG CONFOUNDS AND LUBRICANTS OF HIGH TEMPERATURE ALLOTS AT KLEVATED TEMPERATURES

### ABSTRACT

At the present time, very little information is available concerning the metallurgical effects of antiseizing compounds and lubricants on high temperature alloys at elevated temperatures. This test was conducted to gain some background information in this area.

The test was conducted in two phases. The first phase subjected seven different alloys to the effects of twenty two different compounds at a temperature of 1000F for ten hours. In the second phase, six of these alloys were subjected to twenty of the compounds at a temperature of 1800F for ten hours.

The results of the first phase of the test indicate that none of the compounds tested cause significant change in the microstructure of the alloys, observable at 250X, for temperatures up to 1000F. At 1800F, however, considerable corrosion was present. The type and degree of corrosion varied with the different compounds and alloys.

From the results of this test, it could be assumed that any of the compounds tested would be satisfactory for use on these alloys at temperatures to 1000F, but care should be used in selecting an alloy-compound combination for use in the higher temperature range. It should be noted that this report deals only with the metallurgical effects of the compounds tested on metals in the unstressed condition and no reference will be made to the antiseting, lubricating, or binding capabilities of the compounds. A future series of tests are now being considered for obtaining this information.

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PREPARED BY Billy L Throshy APPROVE	D D Danker
Test Engineer	Senior Engineer, Materials
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Chief, Systems Laboratory  DISTRIBUTION: M. Deutsch, R. F. Johnson, H. S.	Laboratory Project Engineer Hegel (5), E. Welbart E. Pieper

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#### 1. IMPRODUCTION

A number of antiseising compounds, lubricants, and binders are now in use or being studied for use, at McDonnell. Very little information is available concerning the metallurgical effects of these compounds on high temperature alloys at elevated temperatures. The intent of this report is to furnish information in this field.

The information contained in this report is based on the results of tests conducted during the period 1 June 1961 through 18 July 1961, by the Methods Test Group, Bys.ems Inboratory, General Engineering Division of McDownell Aircraft.

The testing was carried out in two phases. In phase one, sets of seven specimens, of different alloys, were placed in twenty three containers were taken ers containing different compounds. After this the containers were taken to a temperature of 1000% and held there for ten hours. In phase two, specimens of six of the above alloys were subjected to twenty one of the above compounds and 1800% for less hours.

It should be noted that this report deals only with the metallurgical effects of the compounds tested, and no reference will be made to the anticeising, lubricating, or binding capabilities of the compounds. A future series of test are now being considered for obtaining this information.

#### 2. DESCRIPTION OF TREE ARTICLES

Seven different alloys and twenty two different compounds were tested, (one container in each of the two phases contained only the specimens and ambient sir) they are as follows:

### 2.1 Alloys

- (A) Incomel X: 0.04C, 0.7 Ma, 0.5 Si, 15 (2, 75 Si, 105, 2.5 M, 0.9 Al, 7 Fe.
- (9) A-286: 0.080, 1.35 No., 0.5 St, 15 Cr, 25 Ro. 1.25 Ro., 2 M., 0.25 Al, 0.3 V, remainder For.
- (C) Neme'41: 0.10, 19 Cr, 11 Co, 10 No, 3 T1, 1.5 A1, 3 Fe, Trace B, Remainder Ei.
- (D) 1-605: 0.15C, 1.5 kg, 0.5 Si, 20 Gr, 10 Ki, 15 W, 2 Fe, Remainder Co.
- (E) Mastelloy X: 0.15C, 22 Cr, 9 No, 20 Fe, Remailler Mi.

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# 2.1 Alloys (cont'd.)

- (F) 310 S.S.: 0.25 C, 2 Ma, 1.5 Si, 25 Cr, 20 Hi, Remainder Fe.
- (G) \$130 SFL: (1000F phase only) 0.3C, 0.5 Ma, 0.04 P, 0.048, 0.3 St, 1 Cr, 0.2 Mo, Remainder Fe.

NOTE: The above figures are approximate percentages of the elements present in the alloys; therefore, they may not add up to 100%.

# 2.2 Compounds

- (A) Silver Goop: (Antiseising Compound) Manufactured by Grawford Fitting Company, Cleveland, Ohic. A metallic, fluid, pasts, designed for use on high temperature alloys, at temperatures up to 2000F. Composition: simminum oxide (Al<sub>2</sub>O<sub>3</sub>), graphite, magnesium oxide (NgO), silver and silica (SiC<sub>2</sub>).
- (C) Ease Off 990: (Antiseising Compound) Manufactured by the Texicomo Company, Dallas, Texas. A thick brown pasts, designed for use at temperatures to 1800F. Composition: molybdenum disulfide (NoS<sub>2</sub>), lead oxide PbO), and graphits.
- (D) Fel-Pro CSA: (Antiseising Compound) Namufactured by Felt Products Manufacturing Company, Skokie, Illinois. A thick metallic pasts, designed for use at temperatures to 1800. Osegosition: colloidal copper base.
- (E) DGF 125: (Lubricent) Manufestured by Miracle Fover Products Corporation, Cleveland, Chio. A black corosol spray. Composition: grephite.
- (F) MIL-2-55kk-A: (Antiesising Compound) The compound tested was menufactured by Fernater Company, Incorporated, Kansas City, Manage. A thick, black paste, designed for use at temperatures to later. Composition: 50% graphite and 50% petrolatum.
- (0) Electrofile 1000: (Embricant) Obscomed somedectured and applied by Dynauraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 1500F. Composition: graphite and lead oxide (StO).

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# 2.2 Compounds (cont'd.)

- (E) Theoretical 1005: (Lubricant) Compound manufactured and applied by Dynaeraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 700F in air (to 2000F in vacuum). Composition: Malyadama disulfide (NoSo).
  - (I) Electrofilm 2006: (Antiseising Compound) Compound manufactured and applied by Dymacraft Corporation, St. Louis, Missouri. A thin black electrically bonded film, designed for use at temperatures to 300F in air (to 2000F in vacuum). Composition: graphite.
  - (J) Electrofilm 660: (Antiseising Compound) Compound manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 6009 in air (to 20009 in vacuum). Composition: molybdenum disulfide (MoSo) and graphite.
  - (K) Phosphethern Rd: (Antiseising Compound) Manufactured by The Alpha Molykote Corporation, Stanford, Commedicat. A coarse, pink, powder designed for use at temperatures to 2200%. Composition: potassium, sodium, and phospherus pentoxide (P205).
  - (L) Molykote I-106M: (Lubricant) Manufactured by The Alpha Molykote Corporation, Stanford, Connecticut. A thin, black, metallic, liquid, designed for use at temperatures to 700% in air (to 2000F in vacuum.) (Exposition: molybianess disulfide (M:82) (Used in 1000F phase 1.79.)
  - (H) Nolyhote X-105: (Lubricant) frame as Nolyhote X-106H with the exception of the material used as a binder.
  - NOTE: The materials listed under composition for the above conservial compounds are only the basic composition. Complete information on the composition of these compounds is, in most cases, unavailable.
  - (W) Sodius Silicate: (Minday) A thick, clear, liquid (MagGiOs)
  - (0) Silica: (Binder) A fine, white powder. (Biog); A.C.S. pure grade.
  - (P) fills of Magnesia (Anticoising Compound) A thick white liquid. Mg(Off): U.S.P. grade
  - (Q) Magnesium Oxide: (Antissising Compound) A fine white powder. (MgO); A.C.S. rengent grade.

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# 2.2 Compounds (Cont'd.)

# PIEAL REPORT

- (R) Boron Mitride: (Antiseising Compound). A fine white powder. (BE); commercial grade.
- (8) Boric Oxide: (Binder) A first white granular compound. (B20g): A.C.S. reagent grade.
- (T) Lead Monoxide: (Lubricant) A fine, yellow, powder. (FbO): H.F. IX grade.
- (U) Calcium Fluoride: (Lubricant) A fine, white powder (Cay): A.C.S. reagent grade.
- (V) Lead Sulfide: (Lubricant) A coarse, black powder. (Fb8); A.C.S. reagent grade.

#### 3. TEST SETUP

Containers for the specimens and compounds were fabricated from 301 S.S. sheet and tube stock. Materials for specimens were obtained and machined, when required, and cut to the required dimensions (see Figure A page 9 ).

For the 1000F phase of the test sets of seven specimens, one of each material type (see Benesigning of Test Articles, Alloys', page 2 ) vere placed in twenty three different containers. The specimens were suspended on stainless steel wire and separated by commic bead spacers so the specimens could not come into contact with each other or the containers. White sand, which was used as a seal to retard the circulation of air into the containers, was added to the outer area of the container. Then the imit area of the containers, which contained the specimens, was blown clean with high pressure air, to remove foreign particles, in preparation for the addition of the compounds and high temperature exposure. (See Figure B , page 10 ).

For the 1800F phase of the test, the same containers were cleaned and roused for their respective compounds. The specimens were placed in their containers in the same manner as for the 1000F phase, except there were only six specimens in each set due to the fact that the 4150 steel specimens were emitted because of the temperature limitations of this material. Also, only twenty one containers were used because two compounds were omitted. One (Cause 425A) was omitted because of temperature limitations, and the other (Rolykote E-1068) because of not being available at the time of test.

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### 4. THE PROCEDURE

All compounds tested, with the exception of the Ricetrofilm series, which were electrically bonded to the specimens by Dynacraft Corporation, 55. Louis, Missouri, were added to the containers after the specimens were nowated in them. The containers were then placed in an air atmosphere furnace, in the Materials and Methods Laboratory, and held at 3000 for approximately one hour to drive off volatile substances. The lids were then placed on the containers and they were subjected to Make temperature exposure.

For the 1000F phase of the test, the twenty-three containers; twenty two contained the various compounds, see "Description of Test Articles, Compounds", page 5) and one, for control specimens, containing ambient air; were placed in an air atmosphere furnace. Then the specimens were bested to a temperature of 1000F and held at this temperature for ten hours, and allowed to air cool to room temperature. The specimens were then removed from the containers, and the containers were cleaned in preparation for use in the 1800F phase of the test.

For the 1800F phase, the twenty one containers; twenty containing the compounds to be tested (see Description of Test Articles, Compounds" page 5) and one, for control specimens, containing subject air; were placed in an air atmosphere furnace and heated to a temperature of 1800F, hold at this temperature for ten hours and allowed to air cool to room temperature. After this, they were removed from the containers to be mounted and polished.

A transverse and longitudinal sample were cut from each specimen. These were mounted in a clear plastic (Spon 828 resin, using diethylense triamine for catalyst). After this, the samples were ground and polished for metallographic examination. The samples from the 1000F exposure were then etched and photomicrographs taken of the transverse samples. Photomicrographs were obtained prior and subsequent to the 1600F exposure tests.

#### 5. TEST RESULTS

The photonicrographs of the transverse samples from the 1000F exposure show that the compounds tested caused no significant charge in the microstructure of the alloys exposed (see Figures 1 through 161) pages 12 through 65.

The photoxicrographs of the 1800F exposure samples (see Figures 162 through 415, pages 66 through 195) show a vide variety of effects, ranging from no attack to very severe corrective action (see Table 1, page 8).

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# 5. TEST RESULTS (Cont'd.)

The results of this phase of the test show that several of the compounds tested would be unsatisfactory for use in this temperature range.

#### 6. DISCUSSION OF THEY RESULTS

The results of the 1800F phase of this test, indicate that three of the compounds tested caused no significant corrosive attack (i.e. the corrosion present was of the same type and did not exceed the rate of corrosion of the control specimens, which were exposed to only air) to any of the alloys tested, for temperatures up to 1800F. These three compounds, Fel-Pro C5-A, Boron Mitride, and Milk of Magnetia, were the least corrosive. At the other end of the scale was Ease-Off 990, Phosphathern RE, Nolykote X-106, and lead sulfide. These four compounds severely attacked all the alloys tested. The corrosive action of the other 13 compounds tested to 1800F varied within the range of these two extremes. Some of these compounds attacked a few of the alloys while leaving the others untouched, and some of them slightly attacked all the alloys. The remainder of the compounds displayed a combination of both of these vices by slightly attacking some alloys and severely attacking others.

These results indicate that certain facts, such as the alloy the compound is to be used on and the amount of corrosion allowable, should be taken into consideration before these compounds are used.

Another factor to be considered in the temperature at which the compounds are used. Since the temperature agreed between 1000F, where no corresion was observed, and 1800F, where considerable corresion was observed, is quite large, the results here are not too conclusive.

#### 7. CONCLUSIOSE

The fact that no significant amount of attack was present on the specimens subjected to the 1000F phase of this test, indicates that all the compounds tested would be satisfactory for use up to this temperature.

The amount of corrosion present on the specimens subjected to the 1800F phase of this test shows that care should be taken in selecting a compound for use in this temperature range.

It should be noted that this report deals only with the metallurgical effects of the compounds tested on metals in the unstressed condition and no reference will be made to the antissising, lubricating or binding capabilities of the compounds. A future series of tests are now being considered for obtaining this information.

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Silver Goop	Good	Accd	Fair	(cod	Cood	Poor
Base Off 990	V. Poor	V. Poor	7. Poor	V. Foor	V. Poor	7. Foor
Fel-Pro 65-A	Good	Good	Good	Good	(lood	Good
DOF 123	Good	Veir	Cood	Good	Feir	Good
MIL-T-5544-A	Fair	Good	Fair	Fair	Good	Poor
Electrofilm 1000	Fair	Fair	Good	Fair	Fair	Poor
Electrofilm 1.005	Poor	Good	Feir	Fair	<b>Fair</b>	Poor
Electrofilm 2007	Fair	Fair	Pair	Pair	Poor	Poor
Electrofilm 660	Fair	Good	Fair	Fair	Poor	Fair
Phosphathers Re	W. Poor	V. Poor	r V. Poor	V. Poor	7. Poor	Y. Poor
Sodium Silicate	Fair	Good	Fair	Poor	Fair	Fair
Silica	Good	Good	Poor	Good	Good	රිංගර

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Good	, Fair	Poar	V. Poor
Corresion is of same type and doesn't ex- ceed rate of control specimens (in air).	Corrected slightly ex- ceeds and/or is of a different type than control.	Considerable amount of corresion is present.	Severe corresive attack is evident.

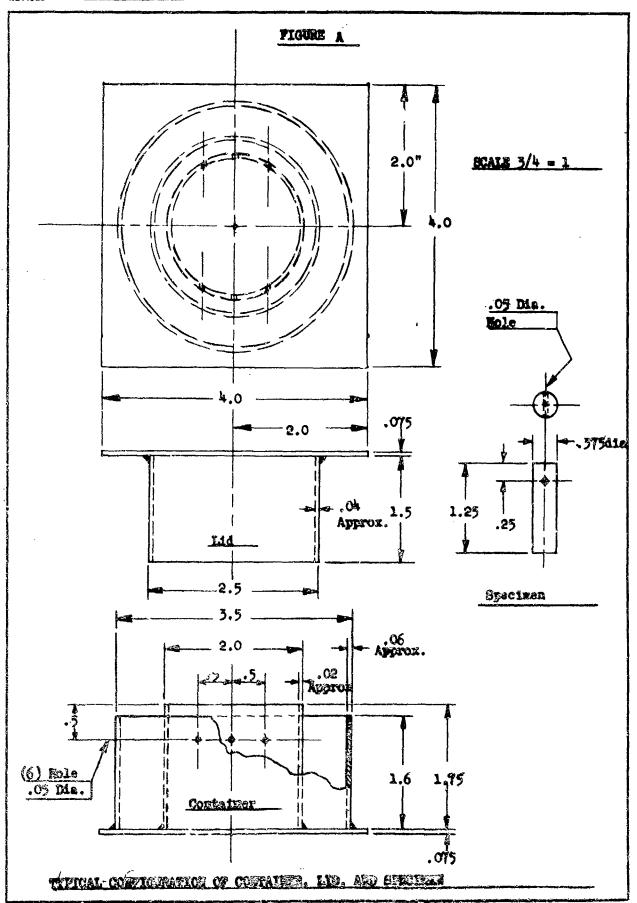
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B. STAINE SS STEEL WIRE

C. CERAMIC BEADS

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SPECIMENS IN CONTRINER

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Etchent Code	Common News	Composition	Alloys Seed Ca
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Incomel X 100 al water 1 ml MAO<sub>5</sub> 5 ml MCl 5 ml glycerism B A-266 Remaikl L-603 Eastalley x Mydrochloric Peroxide C HCI NOT Ego, added by drops as seed-ed. D 10% Commalic 1 ml H2C2O4 9 ml water 310 B.S. (electrolytic) he Calgors, B Picral 4150 Banel U Unatched

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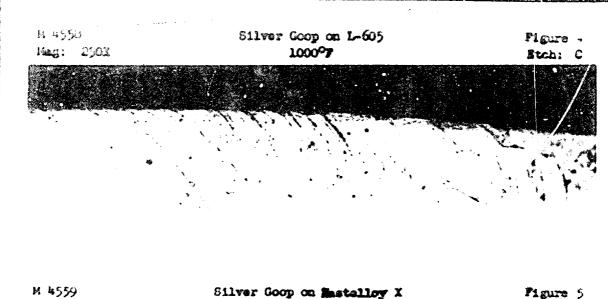
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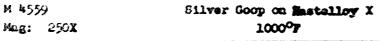
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	Silver Goop on 4130 Steel	Figure 7
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n 4562 Mag: 250X	Crene 425A on Incomel X 1000 <sup>O</sup> F	Figure 8 Etch: A
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PAGE\_ A078 REPORT\_ 124-675710 N 4564" Creeze Will on Rossi W. Figure 10 250X 1000°7 M 4563 Crans \$252 on 1-605 Figure 11 1000°F 29XX Etch: Cross legs on Taxable I Figure 12 Etcht

MANU Sungi Commen 16 A078 REPORT PAR-238311 N 4567 Pigure 13 Creme 425A on 310 88 Etch: 1000°7 Mag: 250X N 4568 Figure 14 Crane 425A on 4130 Steel 1000°F H 4569 Rase Off 990 on Incomel X Figure 15 1000CF Hage 230X Etchi

PAGE REPORT\_ NEW PARAJESTA # 45TD Base Off 990 on A-265 Figure 16 700004 Bich: Mag: 2502 H 4571 Mase Car 950 on Masi 41 Figure 17 10000 Brobs k 4572 Mase Off 990 on 1-605 Pigure 18 100000 Stehn C Magy 2502

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M 4573	Name Off 990 on Nautaliny X	Figure 19
May: 230%	1000°P	Etch: C
n 4574	Base Cff 990 ca 310 86	Figure 20
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Fel-Pro 65-A on Inconel X 1000°F	PAGE 19 REPORT A078  Figure 22 Etch: A
1000°F	Etch: A
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Fel-Pro 65-A on A-286	Pigure 23
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M 4579 Mag: 250X Fel-Pro 65-A on L-605

1000°F

Figure 25

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Fel-Prc 65-A on Hastelloy X

Pigure 26

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м 4582	Fel-Pro 65-A on 4130 Steel	Figure 25
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Sodium Silicate on L-605

Figure 10

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Sodium Silicate on Mestelloy X

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Sodium Silicate on 310 SS

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Pigure 30

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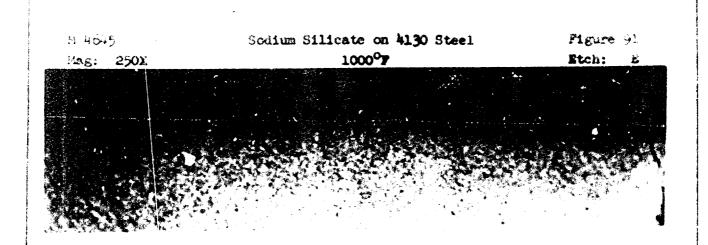
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H 4646 Mag: 250X

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Silica on Incomel X 1000°F

Figure : Etch: A

Silica on A-286 1000°F

Figure 3 Etch: 8 MINONNELL direct Corporation 43

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Silica on Rene' 41 Pagure . 4 ر لهمن ۾ اراد Stch: 0 1000°F FAR: 250X

и 4649 Mag: 250X Silica on L-605 1000°F

Figure 95 Etch: C

м 4650

Silica on Hastelloy X 1000°F

Figure 96 Etch:

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Mag: 250X 1000°P Etch:

Mag: 250X

Silica on 4130 Steel 1000°F Figure 9d Etch: E



и 4653 Мав: 2**50X**  ------ Hilk of Magnesia on Incomel X 1000<sup>O</sup>P

Pigure 99 Stch: A



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125. 250%

Mill. of Magnesia on A-286 1000°F

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Ztch: B

N 4655

Milk of Magnesia on Rene'41 1000°F

Figure 101

Etch: C

B 1656

Milk of Magnesia on L-605

Pigure . .

Yag: 250%

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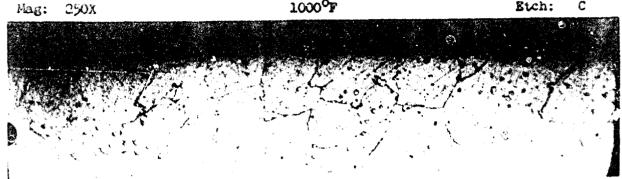
M 4657

Milk of Magnesia on Hastelloy X

Figure 105

1000°F

Etch: C



м 4658

Mag: 250 X

Milk of Magnesia on 310 SS

1000°F

Figure 104

Etch: D

Milk of Magnesia on 4130 Steel м 4659 1000°F

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Figure 105

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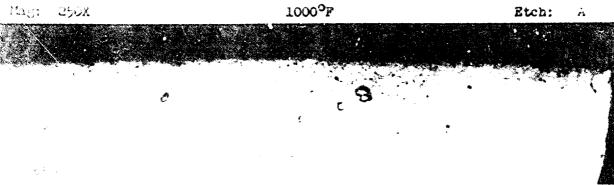
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Magnecium Oxide on Incomel X

1000°F

Figure 100

Etch: A



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Mag: 250X

Magnesium Oxide on A-286

1000°F

Figure 10?

Etch:

May 250X

Magnesium Oxide on Rene'41

1000°F

Pigure 10:

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Magnesium Oxide on L-605

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1000°P

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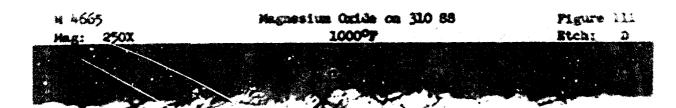
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4 4006 153: 250X

Magnesium Oxide on 4130 Steel

1000°F

Figure lik

Etch:



M 4667

Mag: 250X

Boron Nitride on Incomel X

1000°P

Figure 113

Etch:



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Boron Mitride on A-286

Figure 114

Etch: B

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u 4677	Borte Code on L-605	Figure 123
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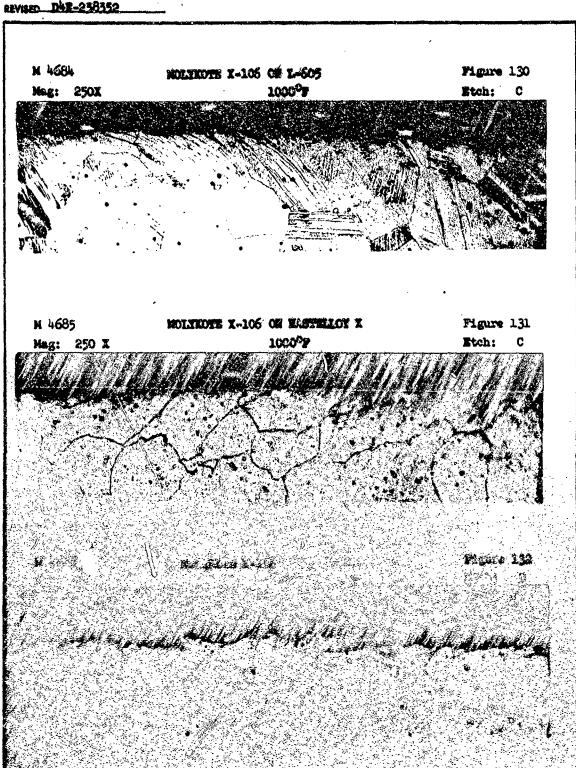
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Mag: 250X	1600*	Rtch: B
Nag: 250X	1600*	Rtch: B
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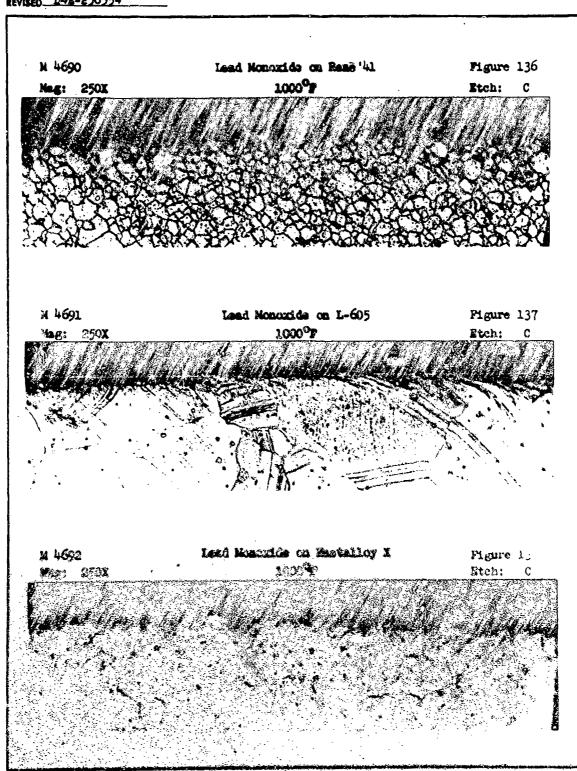
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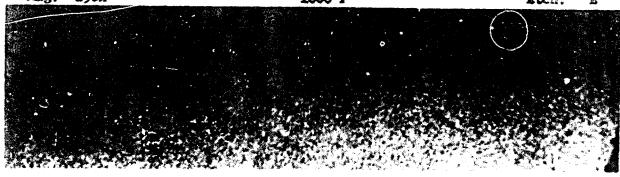
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Mag: 250X

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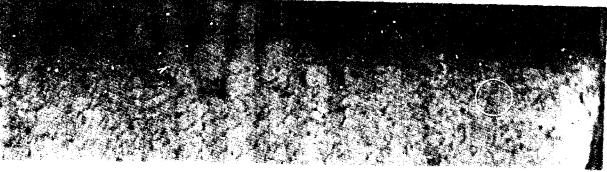


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Calcium Fluoride on Incomel X 1000°F

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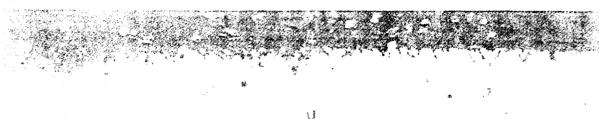
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Silver Goop on A-286.

Figure 163

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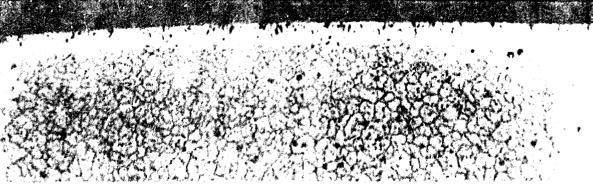
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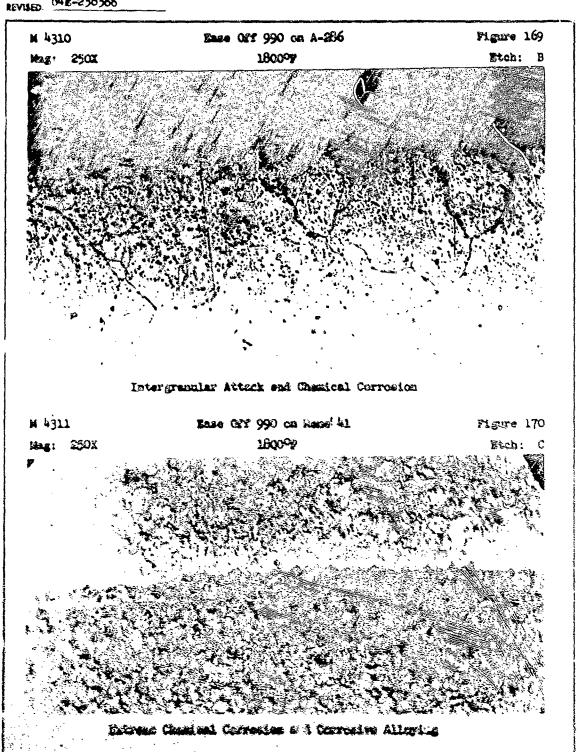
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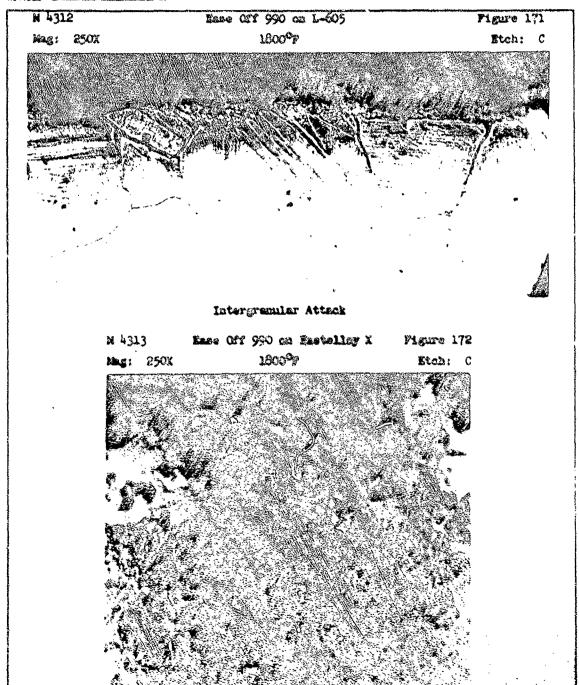
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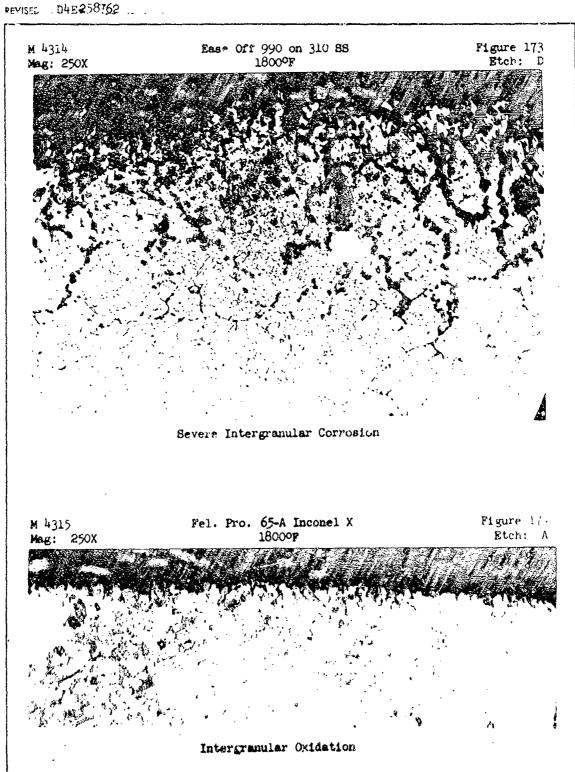
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Figure 175 Etch: B

M 4317 Mag: 250X Fel. Pro. 65-A on René-41 1800°F

Figure 176 .Etch: C

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**M** 4318 Mag: 250X Fel. Pro. 65-A on L-605 1800°F

Figure 177
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Figure 178 Etch: C



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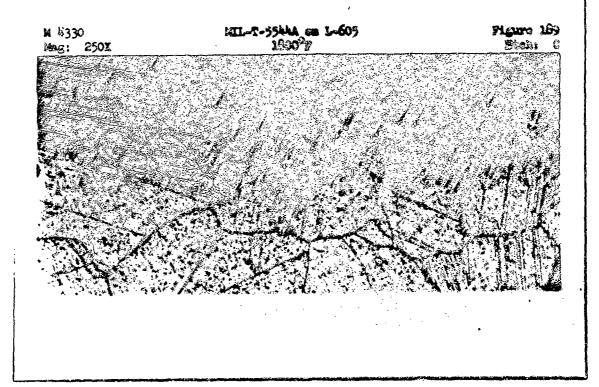
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N 4332

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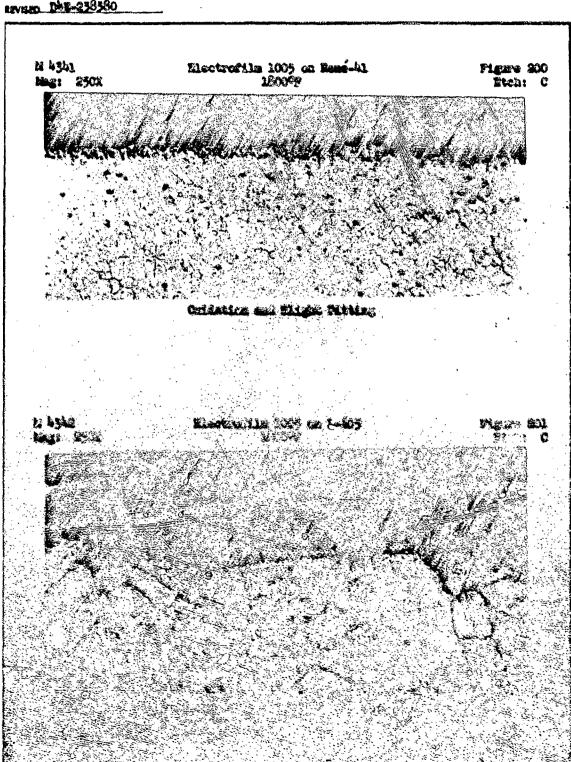
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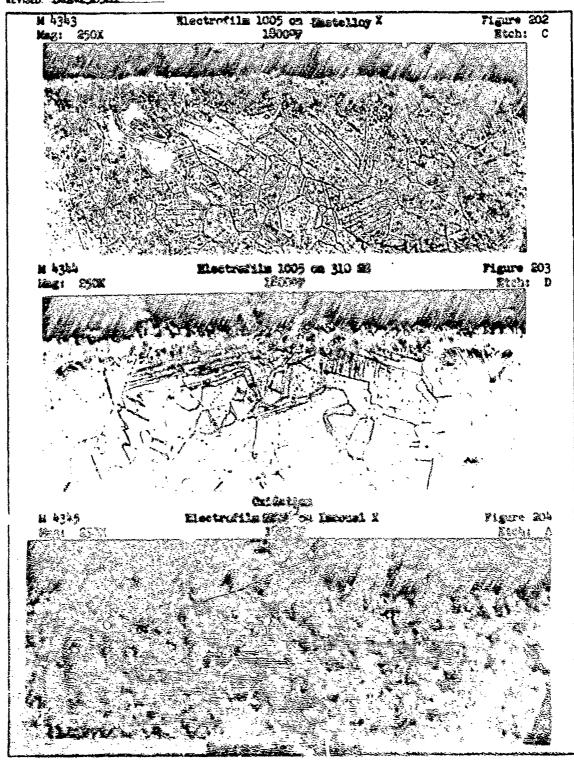
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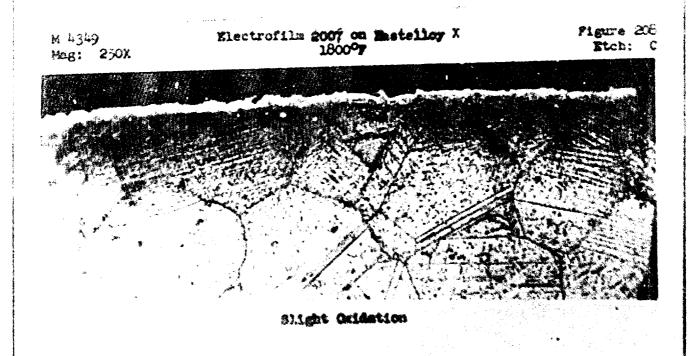
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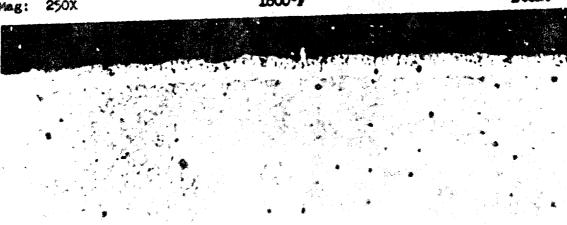
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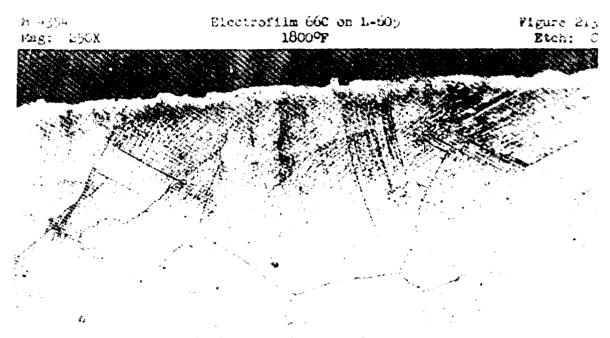
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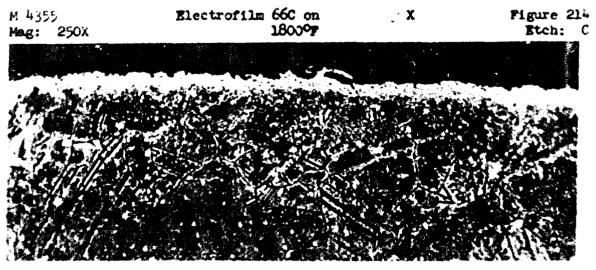
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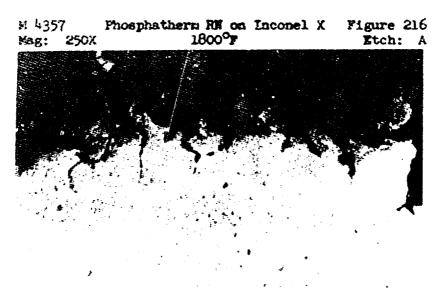
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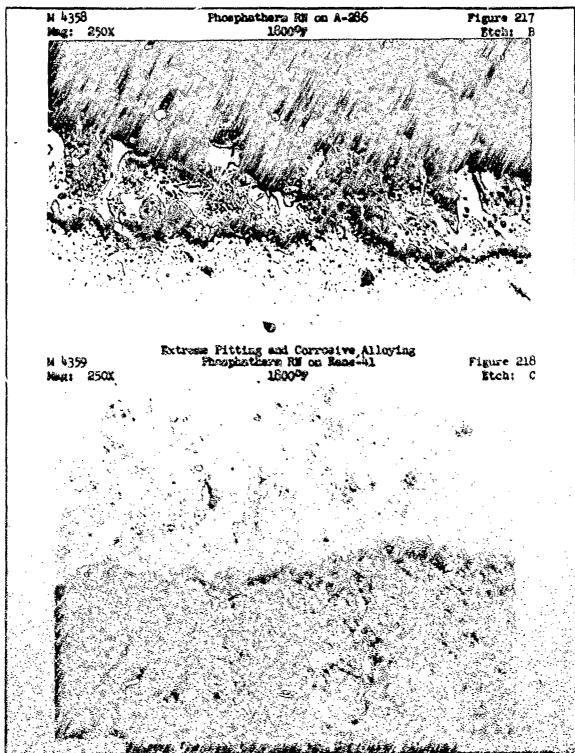
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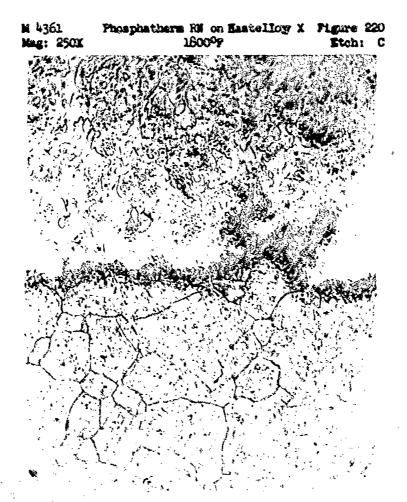
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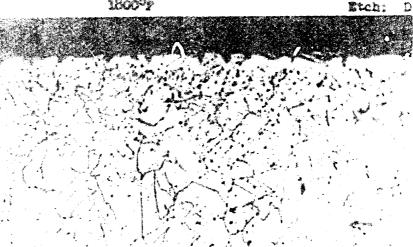
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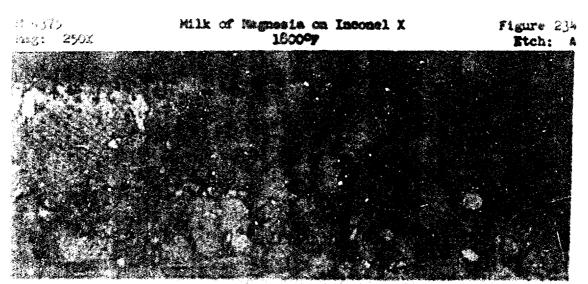
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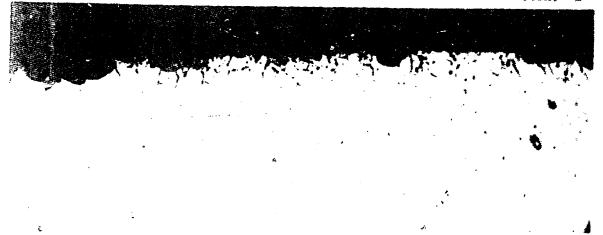
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Pitting and Intergranular Oxidation

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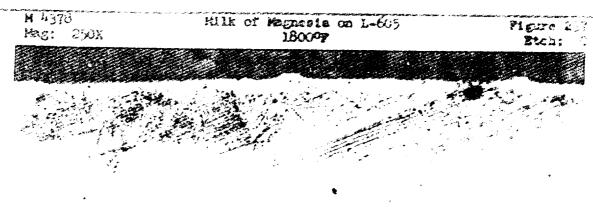
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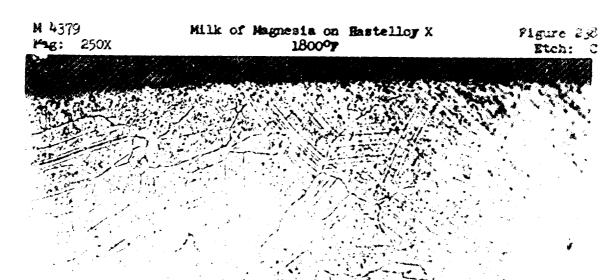
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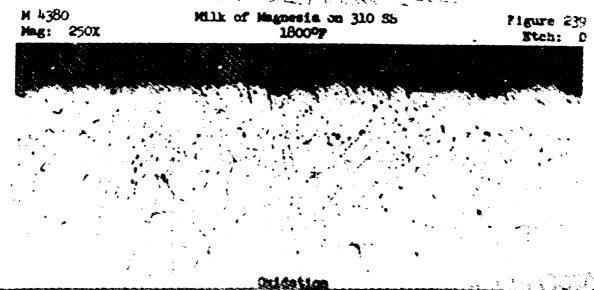
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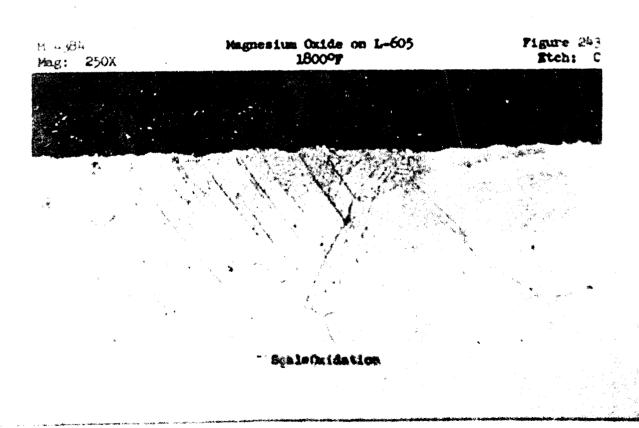


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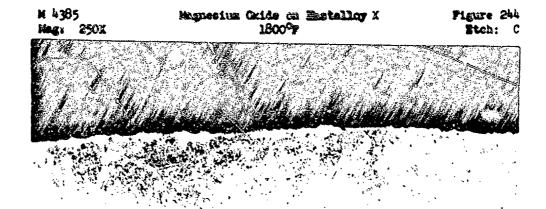
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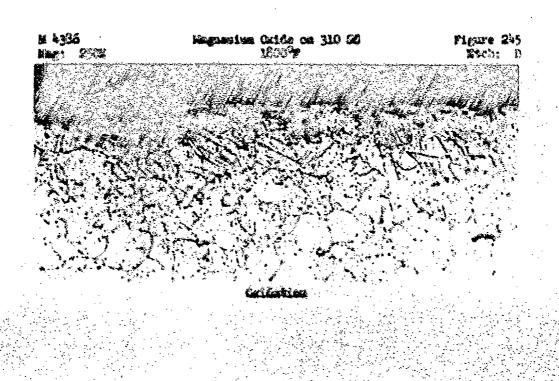
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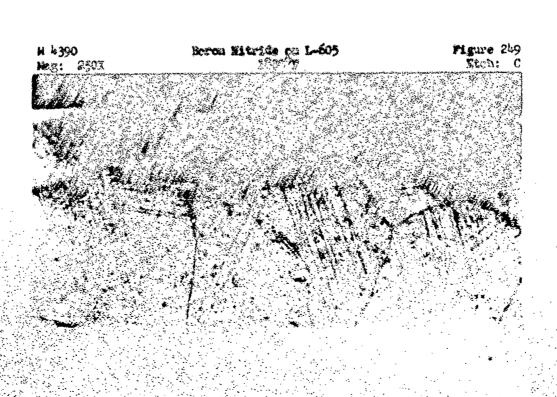
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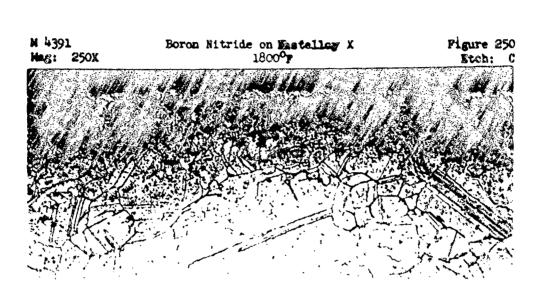
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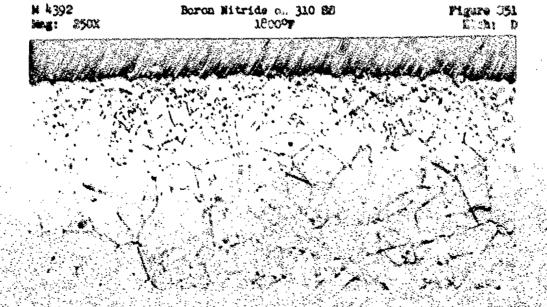
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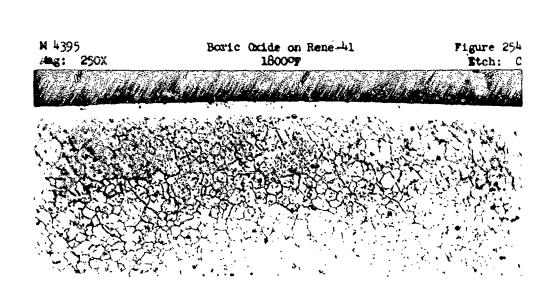
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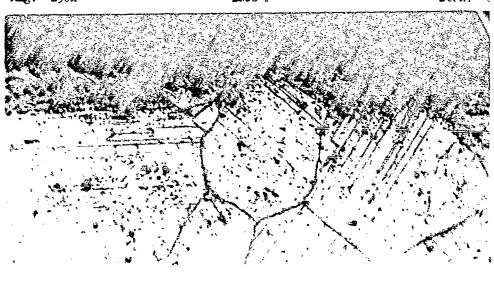
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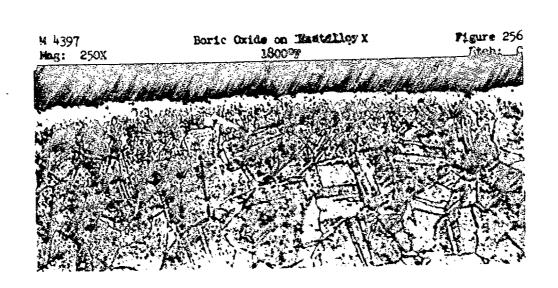
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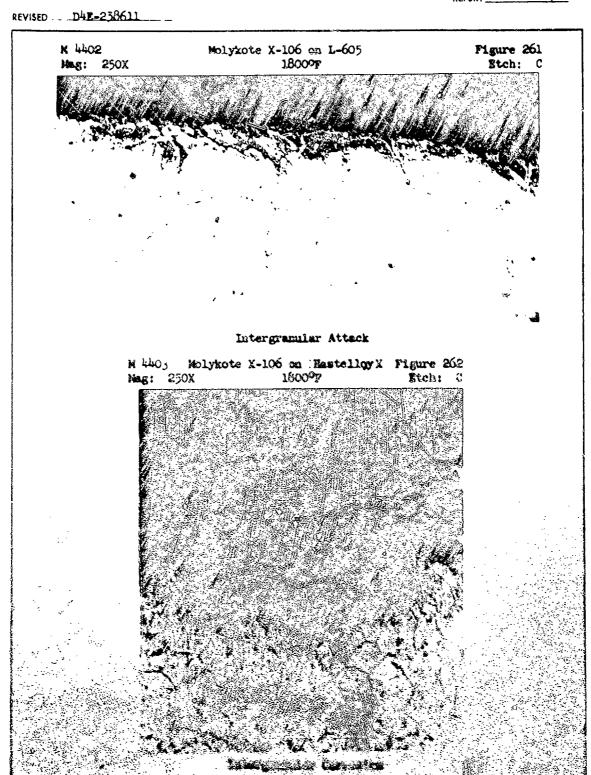
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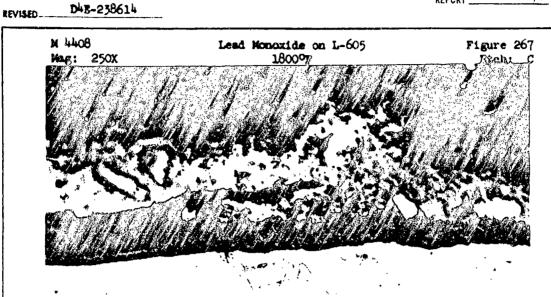
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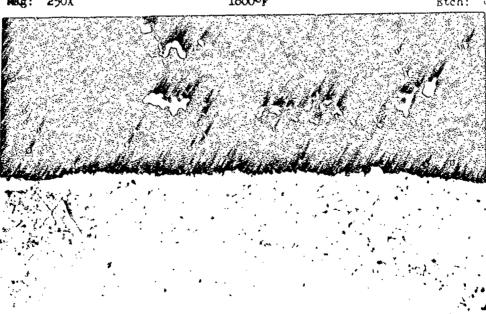
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#### Scale Oxidation

M 5409 Lead Monoxide on Hastelloy X Mag: 250X 18000F

Figure 26% Btch: C



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Mag: 250X

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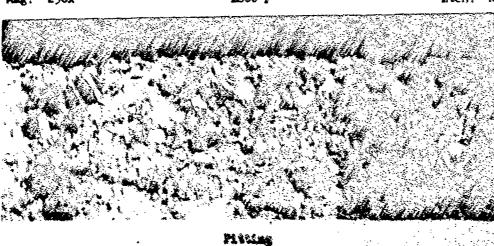
Figure 269 Etch. C



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M 4411 Mag: 250X Calcium Fluorido en Incemel X 1800°F

Figure 270 Etch: A



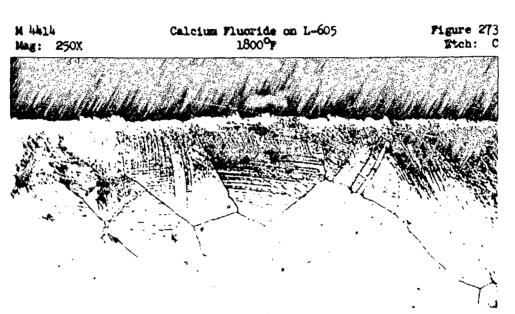
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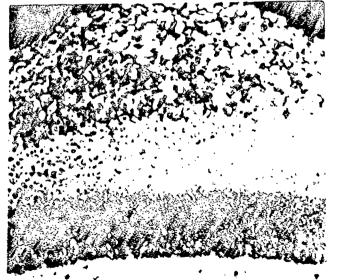
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M 4417 Mag: 250X

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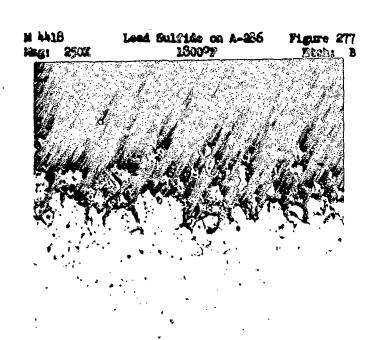
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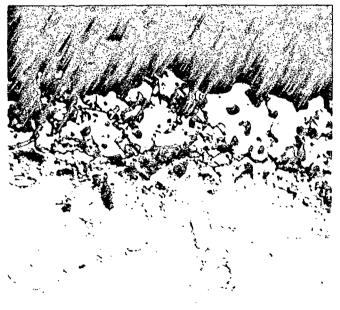
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M 4421 Lead Sulfide on Eastelloy X Figure 280 Red: 250X 1800°F Etch: C



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ISDONNELL Comment 129 PAGE \_ REVELED. A078 REPORT\_ D48-238626 REVISED\_ Silver Coop on Incomel X 1800<sup>Op</sup> Figure 288 Steh: U Mag: 500E Film and Intergranular Oxidation Silver Goop on A-286 180007 Figure 269 Etch: U M 4430 Mag: 500X

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	и 4431 Mag: 500х	Silver Goop on Rané 41 180007	Figure 290 Stch: U
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M 4435 Mag: 100X Ease Off 990 on Incomel X 18000F

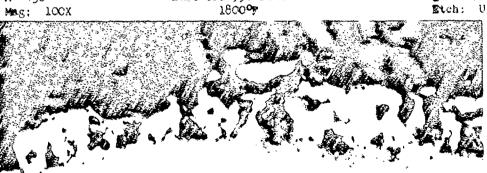
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Extreme Oxidation, Pitting, and Corrosiv. Alloying

M 436 Mag: 100X Ease Off 990 un A- 336

Figure 295



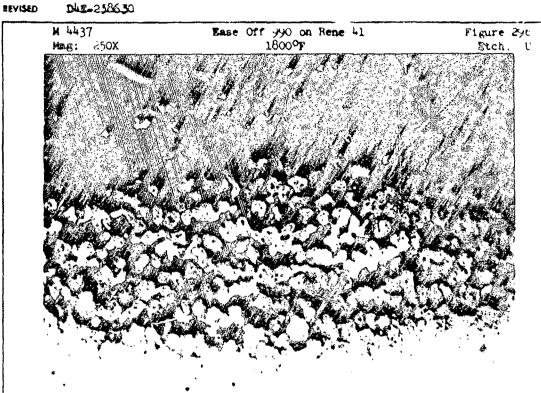
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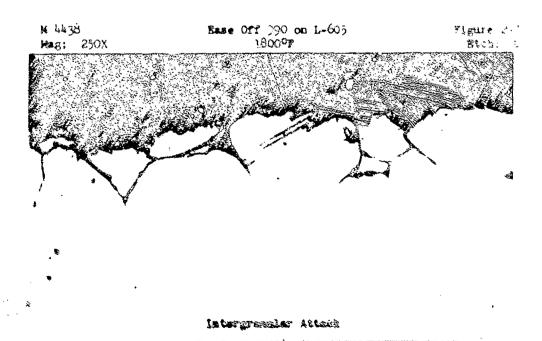
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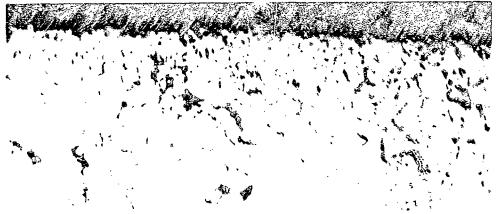
Mag: 100X Base Off 990 on HeatellowX Figure 298
Mag: 100X 1800°F Etch: U

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M 4440

Mag: 250X

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M 4441 Fel. Pro. 65-A on Inconel X Figure 300 Mag: 500X 1800°F Etch: U

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Intergranular Oxidation

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> M 4443 Mag: 500X

Fel. Pro. 65-A on René-41 1800°F

Figure 302 Etch: U

Oxidation

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Fel. Pro. ..65A on L-605 1800°F

Figure 304

Oxidation and Slight Fitting

и 4445 Mag: 500X	Fel. Pro. 65-A on Hastellow X 1800°F	Figure (
-	Slight Oxidation	
и iiiiii6 Мад: 500X	Fel. Fro. 65-A on 310 SS 18000F	Figure     Btch:
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	м 4447	DGF 123 on Inconel X	Figure 306
	Mag: 500X	1800	Etch: U
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		Slight Oxidation	
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м 4449 Mag: 500X

DOF 123 on Rene 41 18000F

Figure 508
Etch: U

Film and Slight Intergranular Oxidation

M 4450

Mag: 500X

DOF 123 on E-605 ... 1800°F

Figure 309

Etch: U

Blight Oxidation

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	M 4451 Mag: 500X	DGF 123 on Enstaller X 1800°F	Figure 310 Etch: U
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	M 4453 Mag: 500X	MIL-T-5544-A on Incomel X 1800°F	Figure 412 Etch: U
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M 4455 Mag: 500X MIL-T-5544-A on René-41 1800°F

Figure 314 Etch: U

Oxidation and Pitting

N 4456

MIL-T-5544-A on L-605 160009

Figure 315

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м 4457 Mag: 500х	MIL-T-5544-A on Eastelloy X 1800°F	Figure 316 Etch: U
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N 4459 Electrofilm 1000 on Encomel X Figure 318 Mag: 500X 1800°F Etch: U

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H 4460 Electrofilm 1000 on A-286 Figure 319
Nag: 500X 18000 Pigure 319
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M 4461 Electrofilm 1000 on Rene-41 Figure 320 1800°F Mag: 500X Etch: U Oxidation and Slight Pitting Electrofilm 1000 on L-605 Figure 321 H 4462 1800°F Bich: U Mag: 500X Oxidation and Slight Pitting

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N 4465	Electrofilm 1005 on Incomel X	Figure 324 Etch: U
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Electrofilm 1005 on Kené-41 1800°F

Figure 326 Etch: U

Oxidation and Slight Pitting

Electrofilm 1005 on L-605 180009

Figure 327 Steht U

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M 4469 Mag: 500X Electrofilm 1005 on Eastelloy X 18000F

Figure 326 Etch: U

Blight Oxidation

M 4470 Mag: 500% #lectrofilm 100% on 31.0 88 180009 Figure 329 Steht V

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H 4472 Nag: 500%	Electrofile 2007 on A-286	Figure 331 Stoh: U
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	м 4473	Electrofilm 2007 on René-41	Figure 332
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	n LL7L Neg: 500x	Electrofile 2007 on L-605 1800-V	Pipre 333 Steh: U
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	M 4475	Electrofilm 2007 on Eastellog X	Planna 37L
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	м 4475 Има: 500X	Electrofilm 2007 on 310 SS 1800°F	Figure 335 Etch: U
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	и 4477 Мад: 500X	Electrofilm 66C on Incomel X 18000F	Figure 336 Etch: U
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M 4479 Mag: 500X Electrofilm 66C on Rene-41

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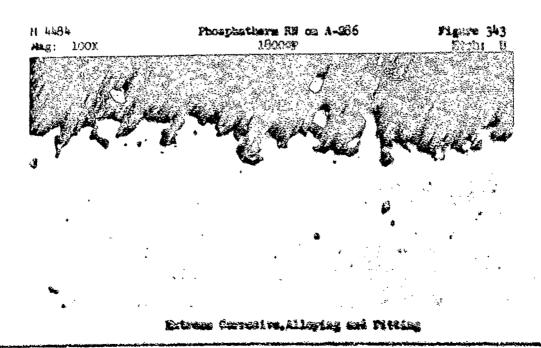
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м 4481 Маg: 500X	Electrofilm 66C on <u>Mastelloy</u> X 1800°F	Figure 340 Stch: U
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	Oxidation and Slight Pitting	
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n 4482 Nas: 500X	Electrofilm 66C on 310 88	n :kosa
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	Electrofilm 66C on 310 88	
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M 4483 Phosphathern RN on Inconel X Pigure 342 Rag: 50X 1800°F Etch: U

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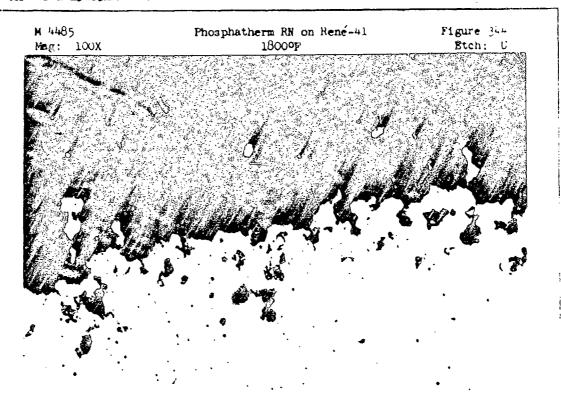
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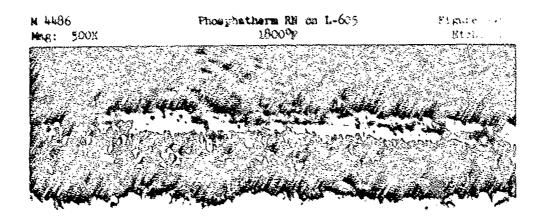
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M 4487

Phosphatherm RN on Hastelloy  $\chi$  18000F

Figure 346 Etch: U

Mag: 100X

Extreme Chemical Corrosion and Corrosive Alloying

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May Phosphatherm RN on 310 SS Figure 347
Nag: 100X 18000F Etch: U

Extreme Pitting and Corrosive Alloying

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Mag: JOX

Sodium Silicate on Inconel X 1800°F

Figure 348 Etch:

Pitting

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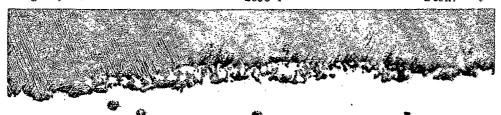
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Mag: 500X

Sodium Silicate on René 41 1800°F

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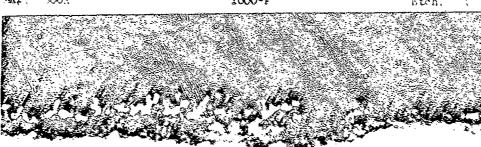


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M 4492

Sodium Silicate on 1-605 1800°F

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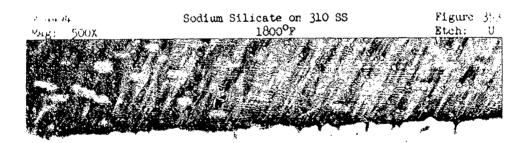
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M 4493 Sodium Silicate on Hastelloy I Mgure 352
Mag: 500X 1800° Etch: U

### Slight Pitting



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м 4495	Silica oa Inconel X	Figure 354	
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n 4496 Nag: 500x	Slight Intergranular Oxidation Silica on A-286 1800°7	<b>Figure</b> 355 <b>Etch:</b> U	
	Silica on A-286		
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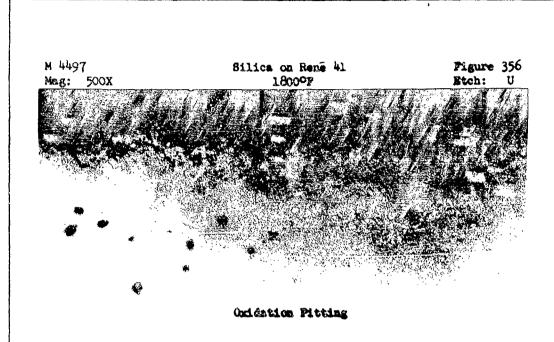
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8644 M Mag: 500X Silica on L-665 1800°F

Figure 357 Rich: U

Might Oxidation

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		<b>,</b>
и 4499 Мав: 500х	Silics on <u>Restalloy X</u> 1800°F	Figure 353 Etch: U
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	Slight Oxidation	
m 4500 Mag: 500X	S1lice on 310 SS 1800 <sup>o</sup> F	Figure 359 Etch: U

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и 4501 Mag: 500X	Nilk of Magnesia on Incomel X 1800°F	Figure 360 Etch: U
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	Film and Intergranular Oxidation	,
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ы 4502 Над: 500%		Figure 361 Biod: U
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Mag: 500X

M 4503

Milk of Magnasia on Rene 41

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Figure 362 Etch: U

Oxidation

H 4504 Mag: 500X Hilk of Hagnesia on L-605 1800°F Piguro 363 Steh: U

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м 4507 Маg: 500X	Magnesium Oxido on Incomal X 1800°F	Figure 366 Etch: U
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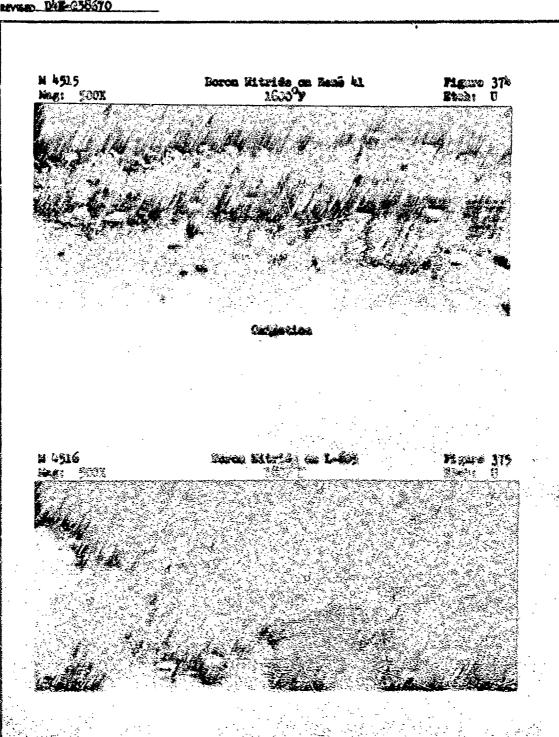
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N 4509 Mag: 500X	Nagnesium Onice on Renë 41 1800 <sup>0</sup> 7	Figure 368 Stah: U
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n 4514	Soron Eltride On A-São 1800°y	<b>Figure</b> 373
n 4514	Soron Eltride On A-São 1800°y	<b>Figure</b> 373
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	N 4523 Nag: 500X	Borie Oxide on Renë 41 1800°7	Figure 380 Steh: V	
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	M 4522 Mag: 570X	Boric Oxide on 1-605 1800°F	Pigure 301 Etch: U	
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M 4523 Mag: 250X	Boric Oziće on 'Mastelloy'i 1800°7	Pigure 382
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Molykote X-106 on Incomel X Mag: 100X 1800°F

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D4R-238676	ST. LOUIS 65, MISSOURI	
N 4527 Hag: 250X	Molykota X-106 on Renë 41 1800 <sup>0</sup> 7	Figure 386 Etch: U
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•	Pitting and Chamical Corresion	
M 4528 Mag: 250X	Pitting and Chamical Correction  Molykote X-106 on L-605 1800°F	Figure 387 Etch: U
M 4528 Mag: 250X	Molykote X-106 on L-605	Mgure 387
M 4528 Mag: 250X	Molykote X-106 on L-605	Mgure 387
M 4528 Mag: 250X	Molykote X-106 on L-605 1800°F	Mgure 387
M 4528 Mag: 250X	Molykote X-106 on L-605 1800°F	Mgure 387
M 4528 Mag: 250X	Molykote X-106 on L-605 1800°F	Mgure 387

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n 4529 Nag: 250x	Kolykota X-106 on Martellar X 1800°F	Figure 368 Steb: U
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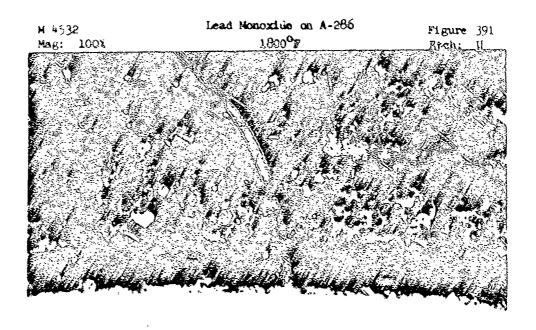
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M 4531 Lead Monoxide on Inconel X Figure 390 Mag: 500X 1800°F Rtch: U

### Chemical Corrosion and Pitting



Oxidation and Pitting

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M 4533 Lead Nomoxide on Rene 41 Pigure 392 Etch: U

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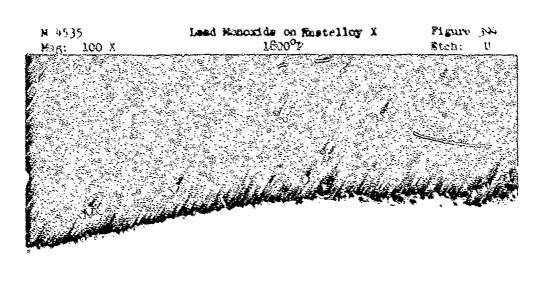
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Lead Monoxide on L-605

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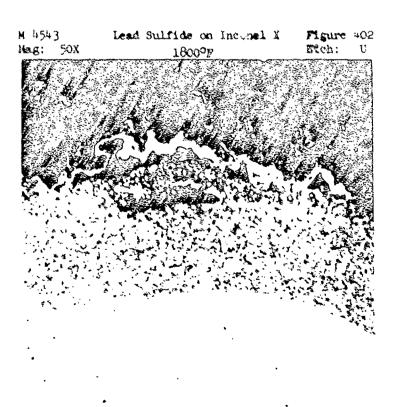
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Meg: 500X

Calcium Fluoride on 310 SS 1800°F

Pigure 401 Etch: U

### Slight Pitting and Intergranular Oxidation



Extreme Corrocive Alloying

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MIDONNELL Swings Comment

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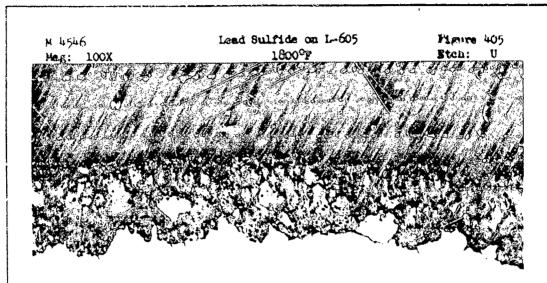
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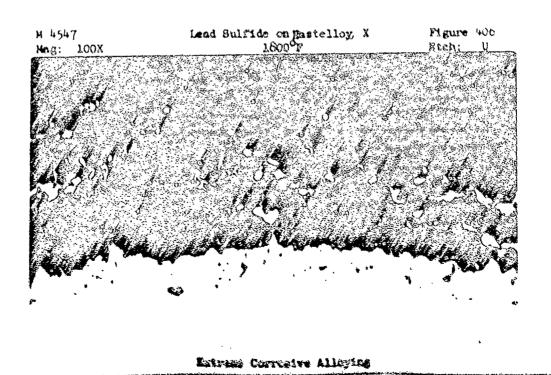
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Extreme Corrosive Alloying



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Intergranular Corrosion

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Pitting

M 4551

Mag: 500X

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TITLE	THE	EFFECT	OF	ANTISEIZING	COMPOUNDS	AND	<b>LURRICANTS</b>

ON HIGH TEMPERATURE ALLOYS AT ELEVATED TEMPERATURE

LABORATORY OR DEPT. RESPONSIBLE FOR YEST MODEL Department 655, Materials Lab Misc. ALTEN TEST PARTS ON ISM : ON THE MO. PRODUCTION PARTS FOR TEST NOT REQUIRED Z

#### WORK REQUESTED

#### OBJECTIVE (GIVE PURPOSE OF TEST, WORK AND DATA REQUIRED. MICLIANCE SERVICE MISTORY AND BACKCOOKED DEFORMATION

OBJECT: Revised pages 1, 2 and 3 to correct callouts and substitute compounds. To determine the metallurgical effect that antiselzing 1. OBJECT:

compounds have on super alloys at elevated temperature.

#### 2. HISTORY:

Œ)

The uses of antiseizing compounds on super alloys, particularly at elevated temperatures, may result in serious consequences. Very little information is available concerning the metallurgical effects when using these compounds.

Work on this T.R. will be done in two phases. The first phase is checking for metallurgical effects on the alloys per the basic T.R. Later, an addendum will be added to check the effect of these compounds in threaded connections.

#### 3. MATERIALS:

3.1	YOLIA	SPEC.	SIZE
3.1.1	Inconel X	ANS 5667 1/4"	to 1/2" dia.
3.1.2	A-286	AMS 5735	X 6.0'*
3.1.3	Rene' 41	Commercial	
	L-605	ANS 5759	1
3.1.5	Hastalloy X	ANS 57508 (8)	
3.1.	310 Stainless Steel	ANS 5651 T	, i
	4130 Steel	MIL-S-6758 Same	die., but
		Cond. C 3 ft	. long

\*Depends on availability. All specs, should be same dismeter.

# 3.2 Compounds

3.2.1 Silver Goop-Jackson Supply Co., St. Louis,

REFERENCES OR ENCLOSURES \*I DEP SUMMARY RPT REQUESTED.
Ru'A" approved: abachman /E.M. Paper

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- 3.2.2 Crane #425A Crane Plumbing Supply Co., St. Louis
- 3.2.3 Easy Off #990 Texacone Co.
- \_322.4 Fel-PRO-C-5 Available at M.A.C.
- 3.2.5 DOZ 123 Maracle Power Products, Cleveland, Ohio

# 6, 3.2.6 Motor Mica Paste - Invricoal Corps - D: 604

- 3.2.7 MII-3-5544A Available at M.A.C.
- 3.2.8 Electrofilm 1000 Dynacraft Corp., St. Louis
- 3.2.9 Electrofilm 1005 " "
- 3.2.10 Electrofilm 2006 " "
- 3.2.11 Electrofilm 66C " " "
- 3.2.12 Phosphatherm RT, alpha Molykote Corp., Stamford, Conn.
- 3.2.13 Molykote X-106M Available in D. 655 Test only at 1000°F
- 3.2.14 Sodium Silicate (powder) Available in D. 655
- 3.2.15 Silica (in solution with acctons) Available in D. 655
- 3.2.16 Milk of Magnesia Available in D. 655
- 3.2.17 Magnesium Oxide (fine powder) Available in D. 655
- 3.2.18 Boron Nitride Available in D. 655
- 3.2.19 Borde Oxide Available in D. 655
- 2 3.2.20 Folyanta I-106 : Available in D. 655
  - 3.2.21 Lead Monoxide Available in D. 655
  - 3.2.22 Calcium Fluoride Available in D. 655
  - 3.2.23 Lead Sulfide Available in D. 655
  - NOTE: If a vehicle is needed for any of the above compounds, contact R. Kollmansberger, D. 1924.

#### 3.3 Fixture Materials

- 3.3.1 301 stainless steel tubing 2 1/2" 0.0. X .065 val thickness X 5' long. 3'2'
- 3.3.2 301 S.S. sheet NIL-S-6029 .090" X 24" X 35"
- 1.3.3 316 s.s. vire (QQ-W-125) .030" dia. X 15'
- NOTE: If 301 stainless steel is not available, use 302, 304, or 321 stainless.

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REP0	RT	<u> 8704</u>

#### . PROCEDURE:

4.1 Specimen Preparation

4.1.1 Cut each bar into 1.25" lengths and drill a 1/8" hole near one end.

4.1.2 Heat treat the alloys of paragraph 3.1 according to the following procedure. All heat treats shall be done in calibrated furnaces.

a. Inconel X
b. A-286
c. Rene' 41
d. L-605
e. Hastelloy X
f. 310 S.S.
g. 4130 Steel

MAC P.S. 15928
MAC P.S. 15602
MAC P.S. 15602
No heat treat req'd.
No heat treat req'd.
MAC P.S. 15013

4.1.3 Machine all specimens to remove scale.

4.1.4 Fabricate test fixture per Figure I. (24 req'd.)

#### 4.2 Testing

4.2.1 1000°F exposure

- a. Place one specimen of each alloy in every container. Each container will then have seven specimens for this exposure temperature.
- b. Add the 23 antiseizing compounds to their individual containers and identify. Make sure that the alloy specimens are not exposed to air. The one remaining container and its specimens will be exposed to temperature without any compound.
- c. Weld shut, and Expose to 1000°F for 10 hrs. Then air cool.
  Remove specimens from the container.

# 4.2.2 1800°F exposure

(For this temperature, the 4130 specimens are omitted.) With a new group of specimens, repeat procedure of 4.2.1 (a) through 4.2.1 (c) except that the temperature is now 1800°F. Expose for 10 hrs., then air cool. If at all possible, use the same containers that were used at 1000°F.

4,2.3 Prepare transvere metallographic specimens of all specimens.

NOTE: The first 9 compounds to be tested are:

Molykote X-106M Silica Lead;Monoxide Tungoten-Disulfide Calicum Fluoride Lead Sulfide Borje Oxide Electrofilm 1000 CBS Process CLD 5940

After these, the order of testing is not important.

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### 5. DATA REQUIRED:

5.1 Photomicrographs at 250X's for each specimen tested.

